Spin Rate Sensor for Fuzing Applications, Theory and Test Results

Presented by: Dale Spencer, Kaman

Co-Authors:

Tim Tiernan, TPL Inc.

Pete Solari, Kaman

Fred Piering, Dayron

Sponsor: W. Konick, ARDEC

Overview

- Theory
  - Magnetic Field Sensor
  - Application
- Test
  - Methodology
  - Hardware
  - Set Up
  - Results
- Conclusions
- What's Next

Roles

- Army Sponsor
  - **Ultra Sensitive Integrated Magnetic Field Sensors For Fuze Applications, Army Contract Number: DAAE30-99-C-1068**
- TPL, Inc **SBIR Phase II Contactor--** Sensor
  - Kaman Subcontractor – Data Recorder and Packaging
  - Dayron -- 40 mm projectile, Range, Test

Spin Rate Sensor Test Team

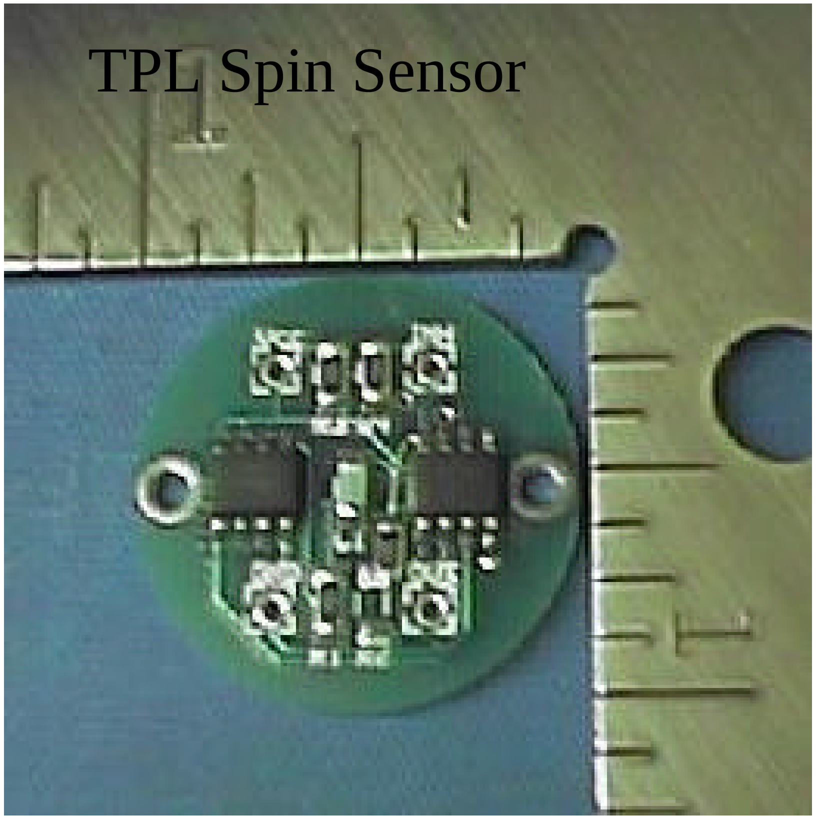
Dale Spencer , Tim Tiernan ,William Konick, Carlos Tessonniere, Jim Nasternak , Kenny LaClair , Wes Sprouse , Pete Solari

Theory -- Magnetic Sensor

- Giant Magnetoresistive material.
- The sensor can detect the ambient magnetic field of the earth with a high signal to noise ratio.
- The response of a GMR sensor is strongly related to its orientation with respect to a magnetic field.
- As the munition spins,
  - the sensor mounted inside changes direction with respect to the earth's magnetic field.
  - a sinusoidal waveform is output by the sensor as it moves from alignment to disalignment with the earth's magnetic field with each revolution of the munition.

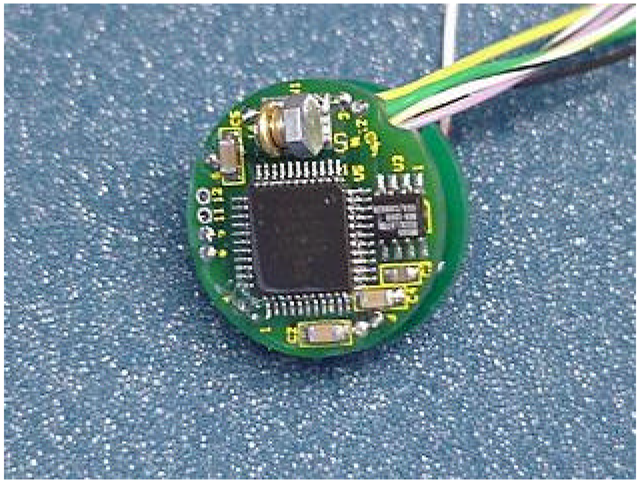
Theory Applied

- Application Theory Developed by TPL, Inc
  - Resolve shell dynamic rotations
  - Rotations for fixed rifling equal distance
  - Multiply rotations to obtain distance



Test Methodology

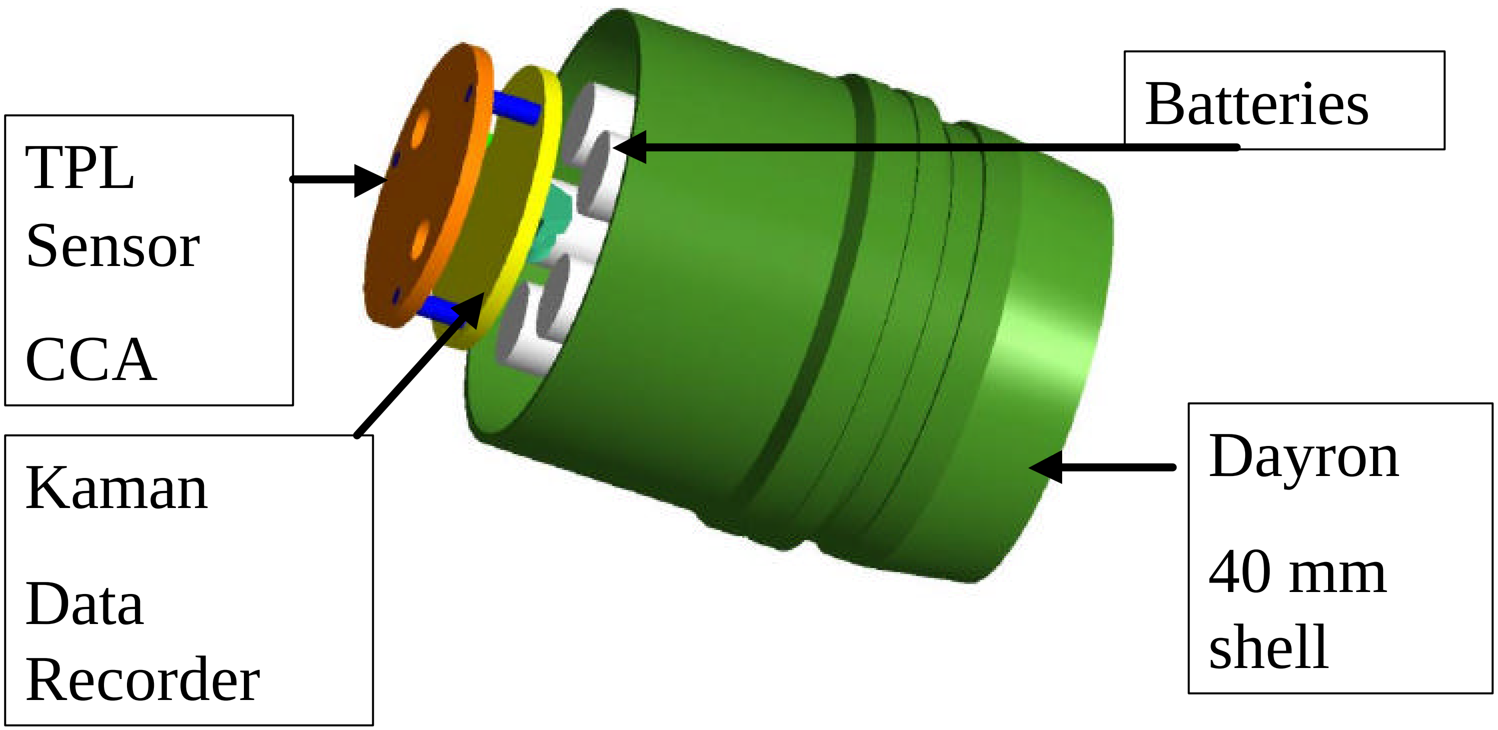
- Dynamic Firing Test
  - Validate Theory through live fire demonstration
  - Build Sensor
  - Integrate Sensor and Data Recorder into projectile.
  - Fire Projectile in Gun with known rifling
  - Measure projectile velocity
  - Compare Projectile turns per second with velocity



KAMAN Data Recorder

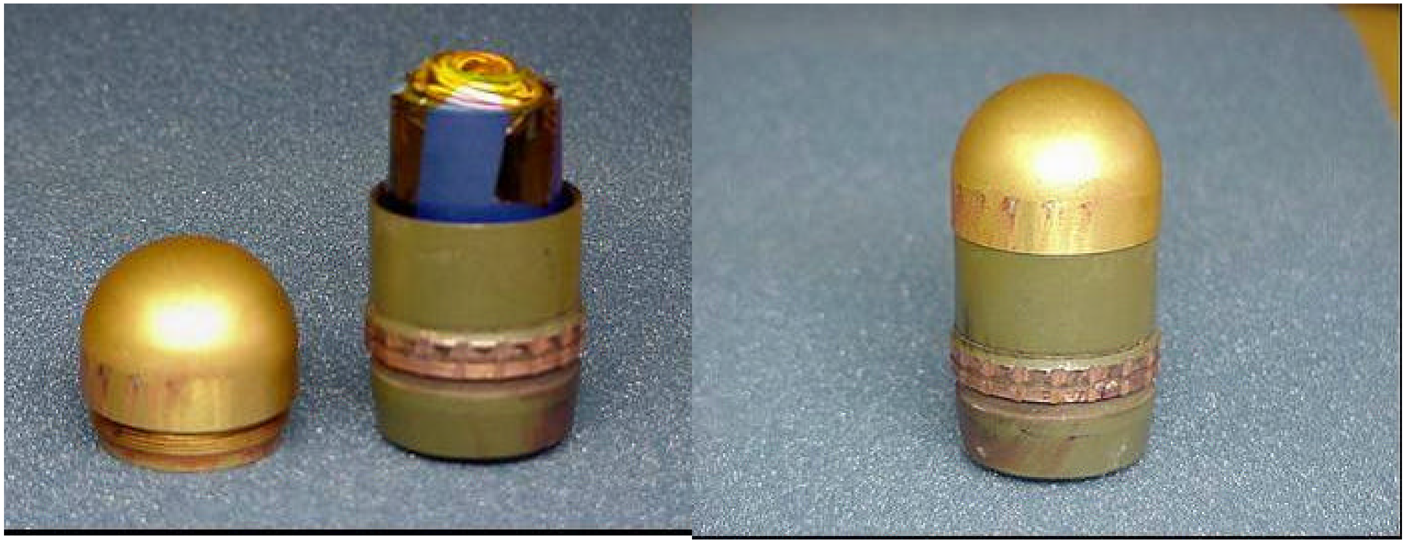
Integrated with TPL Spin Sensor

Conceptual Package for Test



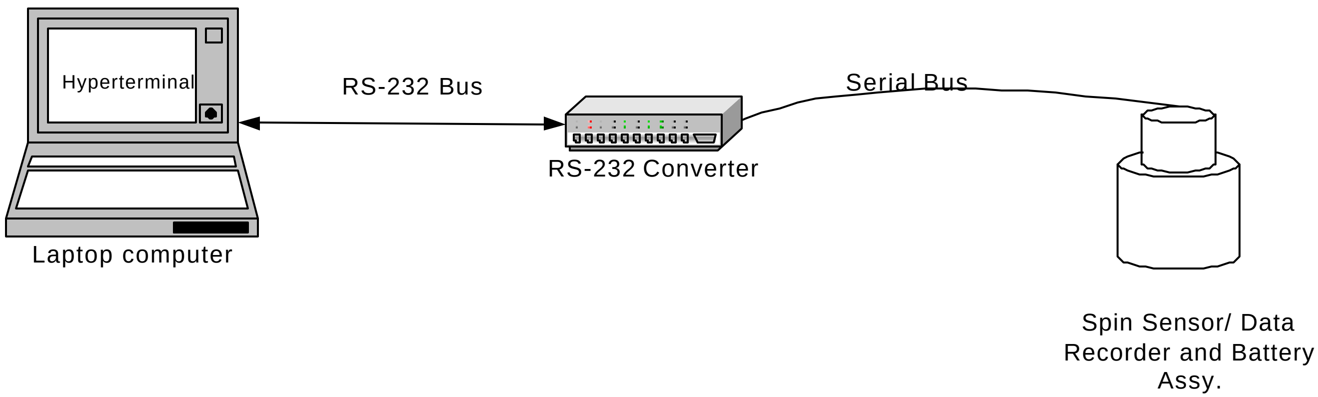
3-D Packaging by R. Spooner, Kaman

Test Projectiles



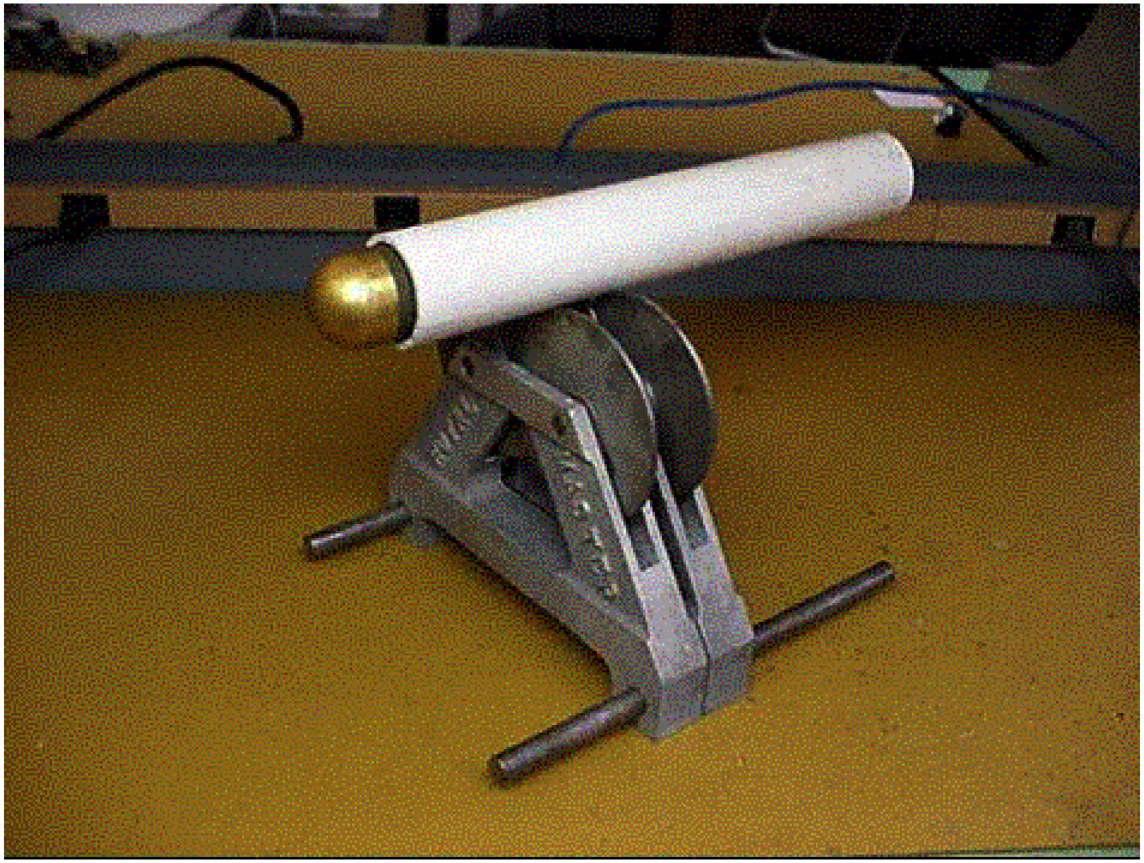
Note: Rifling Grooves, this projectile has been fired and recovered

Data Interface

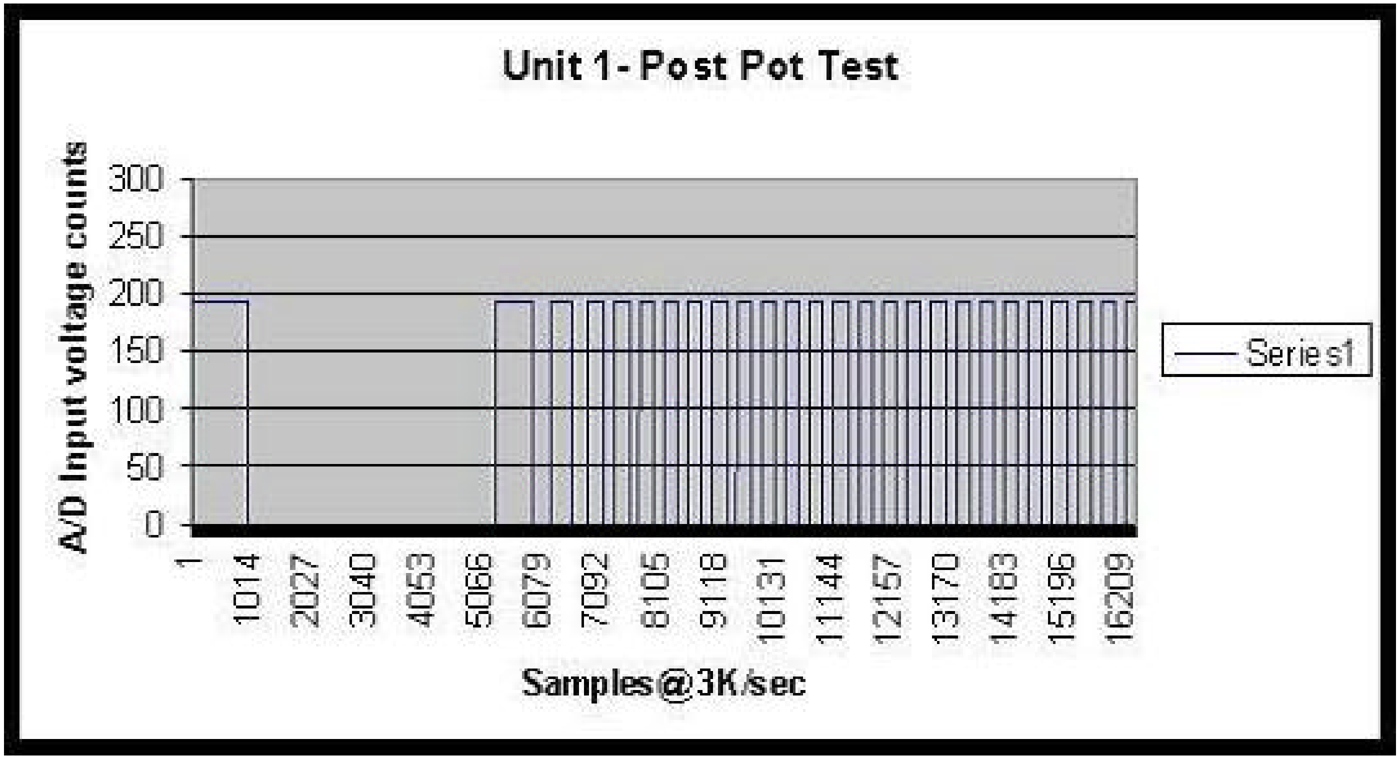


- PC Running Hyperterminal
- Arming Parameters Set Via RS-232 Port
- Data Downloadable To PC's Via RS-232 Port
- All Code Embedded in Recorder
- No peculiar PC software

Bench Test



Bench Test

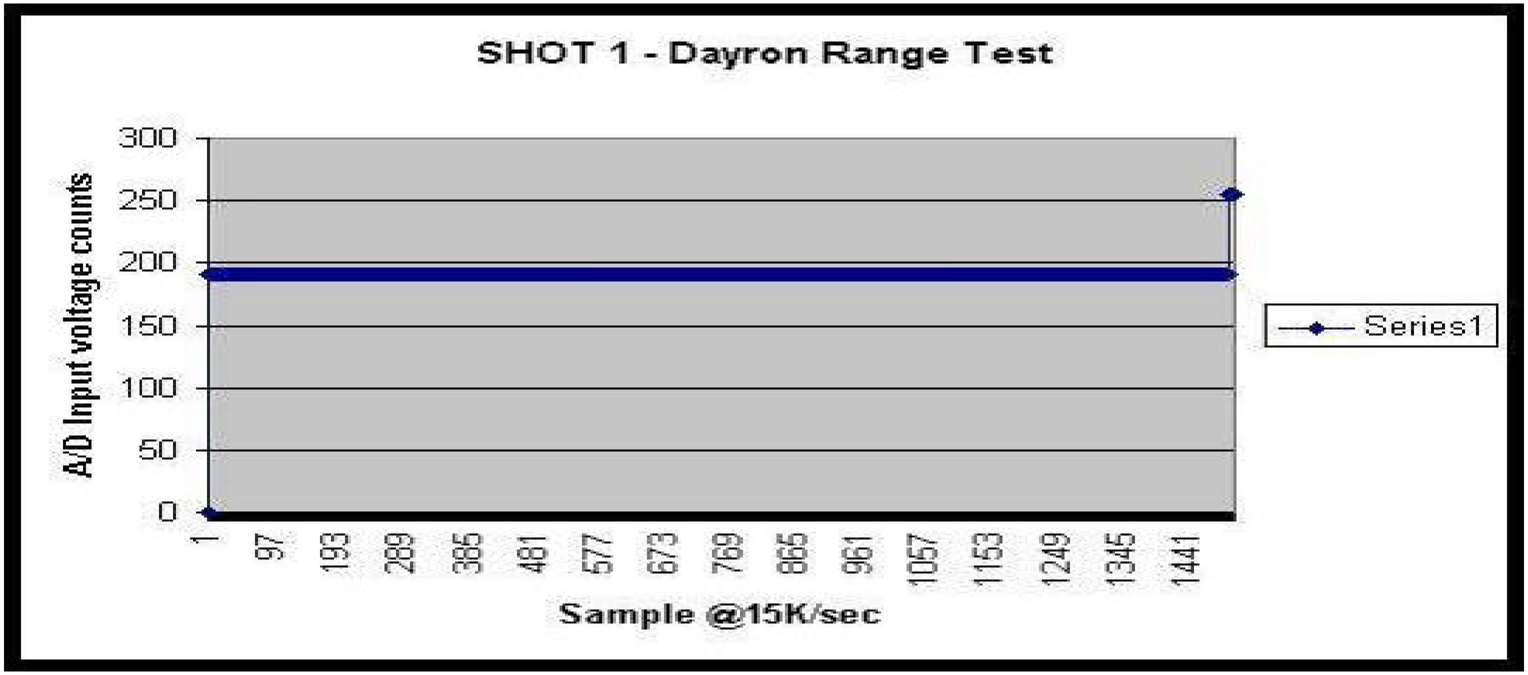


Spin up rate as expected

Transition from low to high as expected

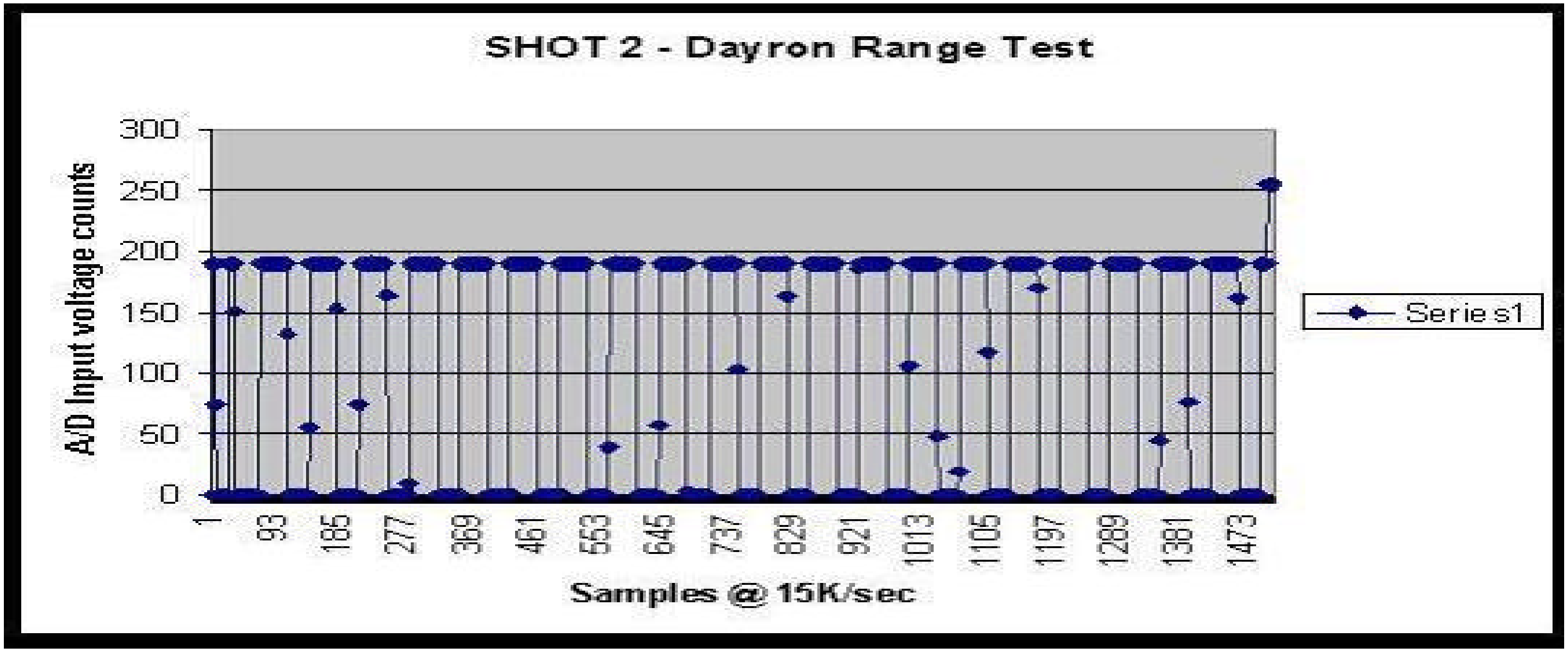
Test Range

Shot # 1 Results



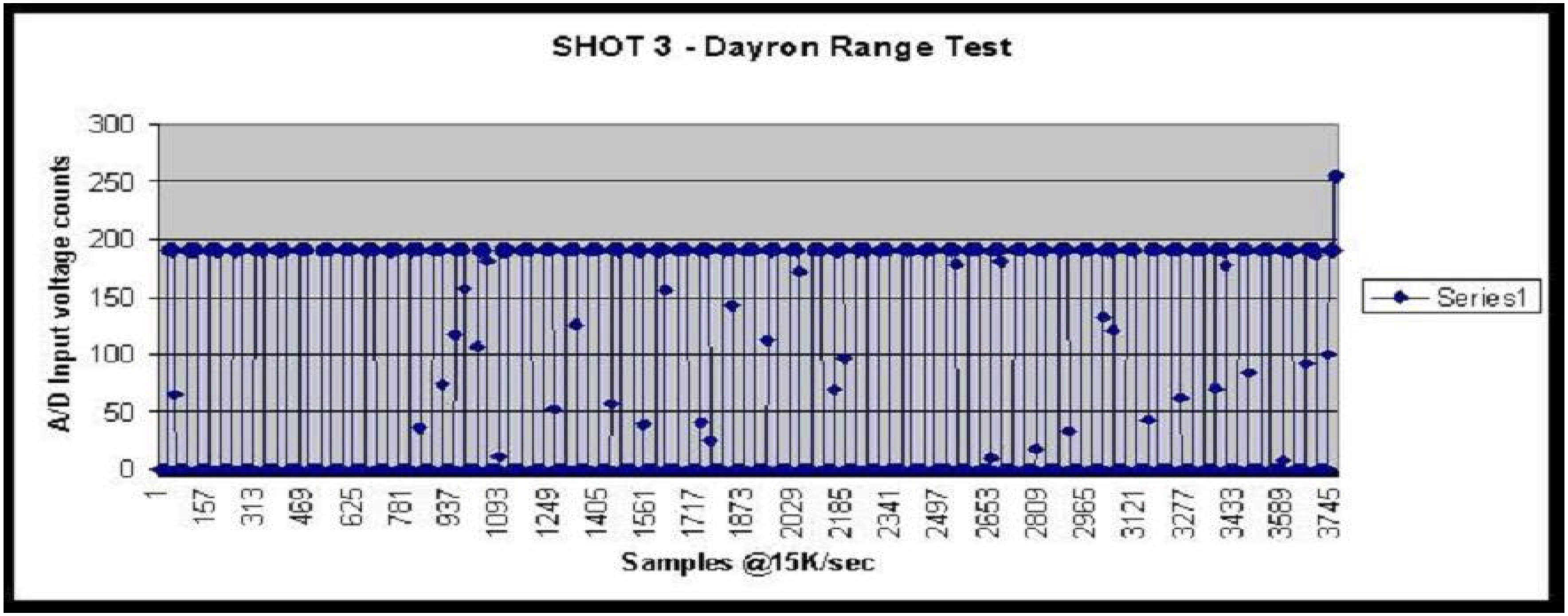
- Flat Line Indicated Problem in First Test
  - First Bit Low and Last High Indicated Recorder OK
  - Digital Value Corresponded to Saturation

Shot # 2 Results



- Interesting Data
  - Calculated velocity higher than expected
  - Decide to measure velocity with laser diode velocimeter for next shot

Test Shot #3



- Good Data
- Measured Velocity = Spin Rate Velocity < 1% error

Test Results

Shot #3	Measured Muzzle Exit Velocity (ft/sec)	Weight (lb)	Number of Turns	Predicted Flight Distance @ 0.25sec Flight Time (ft)	Turns Calculated Flight Distance (ft)	Error (%)
Dayron Round	813	0.740		203.25		
SR Round	831	0.722	51.5	207.75	206.00	0.84

Predicted Flight Distance == Muzzle Velocity * Flight Time = 831 * 0.25 = 207.75 ft

Turns Calculated Flight Distance = # of Turns * 4 ft/Turn = 51.5* 4 = 206.0 ft

% Error = ((Predicted Flight Distance - Turns Calculated Flight Distance) / Predicted Flight Distance) * 100 = ((207.75 - 206)/207.75) * 100% = 0.84%

Conclusions

- Test was a success
- Sensor capable of resolving spin rate accurately
- Sensor is survivable and working immediately upon exit from barrel
- Recorder is survivable and working prior to exit from gun barrel